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A Venue-Based Method for Sampling Hard-to-Reach Populations

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SYNOPSIS

Constructing scientifically sound samples of hard-to-reach populations, also known as *hidden populations*, is a challenge for many research projects. Traditional sample survey methods, such as random sampling from telephone or mailing lists, can yield low numbers of eligible respondents while non-probability sampling introduces unknown biases.

The authors describe a venue-based application of time-space sampling (TSS) that addresses the challenges of accessing hard-to-reach populations. The method entails identifying days and times when the target population gathers at specific venues, constructing a sampling frame of venue, day-time units (VDTs), randomly selecting and visiting VDTs (the primary sampling units), and systematically intercepting and collecting information from consenting members of the target population. This allows researchers to construct a sample with known properties, make statistical inference to the larger population of venue visitors, and theorize about the introduction of biases that may limit generalization of results to the target population.

The authors describe their use of TSS in the ongoing Community Intervention Trial for Youth (CITY) project to generate a systematic sample of young men who have sex with men. The project is an ongoing community level HIV prevention intervention trial funded by the Centers for Disease Control and Prevention.

The TSS method is reproducible and can be adapted to hard-to-reach populations in other situations, environments, and cultures.

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Although hard-to-reach populations may fit well-defined criteria, access to these hidden populations is limited and challenging. Scientifically sound sampling frames or lists do not exist, samples often are numerically small and dispersed over large geographical areas[1] and population members may feel stigmatized, or engage in illegal activities. Traditional sampling methods such as random digit dialing (RDD) allow inference to larger populations,[2] but are not always feasible for hard-to-reach populations. Non-probability sampling methods, on the other hand, raise questions about how well the sample represents the target population. In addition, non-probability methods such as chain referral often are difficult to reproduce systematically.

Other community based techniques, such as street-intercept and respondent-driven sampling, have gained attention recently because they allow access to hard-to-reach populations and address some problems associated with non-probability-based methods. However, these methods do not allow careful quantitative scientific inference. Our application of time-space sampling[3] attempts to retain the rigor of a carefully constructed sampling plan while responding to the challenge of accessing hard-to-reach individuals. It uses ethnographic information to reach the population of interest, and the sampling procedure allows quantitative inference to the larger population.

Only under specific conditions do techniques such as random digit dialing yield large numbers of interviews for sampling hard-to-reach populations. For example, the Urban Men's Health Study obtained a randomly selected population-based sample of men who have sex with men (MSM).[4] Researchers in that study identified specific geographic areas through AIDS caseload data, male-male partnered household data from the US census, addresses from gay oriented commercial mailing lists, and key informants in the gay community. They mapped the data and identified areas with a potentially high density of gay men, then used random digit dialing in these zip codes to obtain their sample.[4] The success of this method is dependent on the ability of researchers to identify specific geographic areas with a high density of gay male households. In smaller cities with smaller populations of MSM, or in geographic areas where the MSM population is dispersed, these sampling methods would be less effective. The random digit dialing method also would miss men who are highly "closeted" or who live outside gay identified areas, as well as younger gay men who may not live in independent households.

Another sampling method used with hard-to-reach populations, particularly injection drug users, is respondent-driven or network sampling,[5] an enhancement of chain referral or snowball sampling that is less subject to bias. Respondents receive incentives for participating in the study as well as for recruiting other eligible participants. Researchers from New Haven, Connecticut, recruited a majority of the local injection drug user population from two cities into their study sample using the respondent-driven procedure.[5] The drawback to this method is its dependence on the selected participants whom the current pool of respondents chooses to bring into the study. The nature of the relationship between respondents may be built on trust, or on psychological dependency on the part of the potential recruit; for example, a drug dealer bringing in his or her clients and insisting on a "cut" of the incentive.

Venue-based application of TSS. Time-space sampling[3] methods provide an alternative to traditional probability and non-probability sampling methods. TSS techniques seek to recruit respondents in places and at times where they would reasonably be expected to gather and to ask them about their experiences within the place or space. For example, information might be gathered from museum patrons about their experiences within the museum.[6] The space or venue affords convenient access to the target population. Researchers are not limited to gathering data exclusive to activities occurring within the venue, although the venues do act as *screeners* in identifying potential respondents. Thus, as with any screening technique, the initial method (identification of venues) should be highly specific for the characteristic(s) being sought, and the follow-up method (the eligibility interview) should be highly sensitive for that characteristic(s). To ensure a systematic sample, researchers need to understand the target population's attendance habits at the venue as well as their likely responses (in this case eligible or not eligible) to a screener questionnaire.

We illustrate the venue-based application of TSS in the Community Intervention Trial for Youth (CITY) project, funded by the Division of HIV/AIDS Prevention, Centers for Disease Control and Prevention (CDC). CITY is an ongoing six-year project begun in October 1996. It is designed to evaluate the effects of a multicomponent, community level intervention aimed at promoting safer sex behavior among young men 15-25 years of age who report having sex with other men. Thirteen sites, representing diverse race and ethnic populations in urban and suburban areas, implement time-space sam-

pling as part of the evaluation design. Six communities were randomly allocated to an intervention, six to a comparison arm; the last community is conducting a detailed case study.

Intervention. The intervention consists of social marketing material, small group workshops, social events with embedded HIV prevention messages, development or enhancement of a peer outreach program (the Community Health Advisors Network), and technical assistance designed to increase the capacity of local organizations to deliver HIV prevention and other services to young men who have sex with men (YMSM). This intervention is being evaluated through a series of annual, cross-sectional, confidential surveys of YMSM who live in the intervention and comparison communities and, thus, may be exposed to the intervention. These surveys began in Summer 1999, prior to the implementation of intervention activities, and will be repeated every summer through 2002, when intervention activities will be completed. Men who are surveyed in one wave of data collection may be interviewed in subsequent waves; however, because we do not ask for unique identifying information, data obtained from respondents cannot be linked from one data collection wave to the next. All sites follow a common protocol that uses the venue-based application of TSS.

Young men who have sex with men have characteristics that make them a hard-to-reach population even with a venue-based approach. Due to age restrictions for entering many establishments where gay men socialize, young men are less likely to be found at venues, such as bars,[7] where older men who have sex with men are found. In addition, YMSM who belong to racial or ethnic minorities may identify more with their ethnic groups than with the gay community,[8] and may not frequent well-known gay-identified establishments.

To address such issues, the CITY sampling design adapted the venue-based approach used by the Young Men's Survey (YMS),[9] an HIV-prevalence survey funded by the CDC. The Survey combined outreach techniques with standard sample survey methods to enumerate, sample, and estimate the prevalence of human immunodeficiency virus type I infection, and related risk behaviors, among YMSM who frequent public venues.[9] YMS researchers identified all public venues within a defined geographic area that were frequented by YMSM. The young men attending the identified venues who met the survey eligibility criteria (similar to the criteria in our survey) were enumerated during various times and days to construct a list of venues and their potential associated sampling periods. Time periods that researchers determined were likely to yield fewer than seven eligible young men in a four-hour period were eliminated; remaining time periods were placed in a sampling frame. Venue-specific day-time periods were randomly selected each month from the sampling frame to construct a monthly sampling-event calendar. In accordance with the sampling-event calendar, young men who appeared to the researchers to be age eligible were consecutively enumerated, approached, screened, and offered enrollment in the survey if determined eligible.

METHODS

The theoretical basis for the method is time-space sampling[1,10] in which time and space define the primary sampling units. In the venue-based application spaces, or locations, are venues attended by the target population; times refer to specific days and time periods when the target population congregates in each space. These spaces and their associated days are divided into standardized time segments (four-hour intervals in CITY) and are referred to as venue-day-time, or VDT, units. For example, a club that is open Friday and Saturday from 10 p.m. until 2 a.m. is divided into two VDTs (Friday: 10 p.m.–2 a.m.; Saturday 10 p.m.–2 a.m.). The universe of VDTs, approximately 300 in our study (this number varies month to month), attended by the target population comprise the primary sampling units in which members of the population are systematically identified and surveyed. Thus, the application of TSS has a two-stage sampling design: VDTs are first randomly selected from a sampling frame, then members of the target population are systematically approached during the VDTs.

Construction of the sampling frame. In CITY, venues were initially identified by researchers who interviewed service providers[11] and men from the community, read gay-oriented magazines and other publications, and kept in contact with the target population (word of mouth). They identified days and times when men might attend the venues, and used the results of these investigations to decide which venues to investigate further. CITY investigators wanted to ensure that some venues with low attendance were included, as those venues often were not gay-identified and have seldom been included in previous research on YMSM; and also wanted a diversity of venues so that bars and clubs did not dominate in the sampling frame.

Prioritizing VDTs to enumerate. Our formative work generated large numbers of prospective VDTs. Before entering a VDT into our sampling frame, we evaluated the feasibility of conducting sampling events at the venue using criteria such as interviewer safety, venue owner permission to collect data, and physical layout of the venue adequate to allow us to conduct interviews confidentially. We further evaluated VDTs using two kinds of enumeration data.

Type I enumeration. The purpose of Type I enumeration was to assess whether the VDTs identified through formative data collection actually were attended by individuals from the target population. During Type I enumeration, individuals who appeared to be members of the target population were counted as they entered a venue during a designated day and time period. In the CITY Project, some of the catchment or study areas target young men of a particular racial or ethnic group. During Type I enumerations, CITY sampling teams during a designated 30–60 minute time period counted the number of men entering the venue who looked to be 15 to 25 years old and of the racial or ethnic background of interest. While no profile training occurred, interviewers were sometimes of the same ethnicity as the target population. The number of individuals counted was used to estimate how many prospective respondents might enter the venue during a VDT of standard length that included that time period, using a standardized enumeration formula:

$$\text{Standardized enumeration} = \frac{\text{Number of men counted} \times \text{Standard VDT length}}{\text{Time (in hours) at the venue}}$$

The standardized enumerations were used to determine which VDTs had too few potential respondents to merit collecting data. Each catchment area had different thresholds to determine which VDTs to keep. Type I enumerations are optional when other forms of participant observation, such as windshield surveys (driving around a neighborhood to observe a population or area), clearly indicate that a venue is attended by large numbers of the target population.

Type II enumerations. The purpose of Type II enumeration is to estimate the number of eligible individuals who will enter the venue during a designated day and time period, also called the effective yield. During Type II enumerations, individuals who appear to be eligible are counted (as in Type I enumeration) and complete brief interviews to determine their eligibility for the longer assessment. To avoid selection biases that can result when interviewers choose whom to approach and whom to ignore, potential respondents are systematically approached as they cross a predefined line or enter a predefined area. In large venues, some potential respondents inevitably are missed when all field staff are busy interviewing young men. The effective yield is calculated using the following formula:

$$\text{Effective Yield} = \text{Screening Fraction} \times \text{Eligibility Fraction} \times \text{Mean of the Standardized Enumerations}$$

The screening fraction is the proportion of people who complete the screener among those who are approached. The eligibility fraction is defined as the proportion of screened people who are eligible. Eligibility for the CITY Project requires that the respondent: 1) must be 15 to 25 years old (except in one catchment area where the age eligibility was changed to 18 to 25 years old); 2) had sex with a man in the past 12 months; 3) is a resident of the catchment area; and 4) in some sites, self-identifies as being part of a specific ethnic group or race.

The effective yield estimates the number of interviews a VDT has the potential to generate during a sampling event. Researchers may choose to discard VDTs that may not yield a sufficient number of interviews, as the YMS project did, or may classify day-time periods based on their targeted sample composition. We used the effective yield to designate VDTs as large or small, and to stratify our VDT sampling frame by size in order to guarantee that men attending small VDTs were adequately represented in our sample. Other researchers who are interested in ensuring adequate numbers of smokers, for example, can screen for specific measures of smoking and then stratify VDTs with high or low effective yields for smokers.

After venues, days, and time periods have been identified, a set of unique VDT units is compiled. Although VDTs can be of varying duration, in the CITY project all VDTs are 4 hours long because this duration fit attendance patterns of YMSM in most of our venues and it proved a reasonable length of time for interviewers to work.

Special venue day-time periods. In the formative research process we identified settings or events known to attract members of the target population that did not recur frequently enough to be placed on a periodic calendar or that occurred during unpredictable times or at unpredictable locations. Because these occasions may attract

members of the target population who do not attend the VDTs already included in the sampling frame, we created three types of special VDTs.

The first is a wildcard, an event that takes place once a year during the sampling wave that may attract a large number of eligible respondents, such as a gay pride event, an annual picnic, or a health fair. Wildcards are placed on the sampling calendar non-randomly. The second type of special VDT is an unknown location-day-time (ULDT), an event that takes place during a specific day and time but the location may vary; a monthly house party, for example, sponsored or hosted by a well-known individual or group, such as a social club. The third type is a known location-unknown day-time (KLUDT) period, a venue that will permit researchers to collect data only on specific days and at specific times that are not known when VDTs are randomly selected. For example, if several projects are trying to collect data at a particular venue, the health department may schedule different projects to sample on specific days and times. Both ULDTs and KLUDTs belong in the sampling frame and are selected randomly with other VDTs.

Special VDTs allow adaptation of the venue-based application of TSS to different settings while maintaining a systematic approach in the selection of venue-day-time periods.

Stage 1, venue selection. After a sampling frame has been developed, VDTs are selected at random on a monthly basis and may be stratified by size prior to selection, as in the CITY project. VDTs were selected with equal probability within the strata of large and small venues, with the exception of wildcards, which were selected with a probability of one. For the CITY project, 60% of the sampling events scheduled each month are small, and 40% are large. In constructing our sampling calendar, we first scheduled wildcards in place of large VDTs, then scheduled the remaining VDTs in the order of their random selection. In case a VDT was poorly attended during a given sampling event, we also scheduled alternate VDTs for each VDT.

Because venue attendance patterns vary for almost any population, our sampling frames are updated monthly, which allows us to respond in a timely manner to changes in venues and attendance patterns. VDTs can be modified, dropped, or added, and VDTs that are dropped can be re-introduced. While the frequency of monthly updates is not always sufficient to respond to changes in VDTs, scheduling survey staff on shorter notice is not always feasible.

Stage 2, participant recruitment. In Stage 2 of our method we recruit men for interviews, using the procedures described for Type II enumeration. Prospective participants are approached, screened and, if eligible, asked to participate in the study. During the screening process we ask individuals if they have already participated in the study in order to avoid recruiting a respondent more than once during a single sampling wave. (In one study using TSS methodology,[9] researchers were able to remove duplication in their sample by using participants' serum samples to obtain genetic markers.) We also monitor how many previous respondents attend each venue to assess the extent to which we have saturated its attendee base. To avoid collecting a majority of our data from any one VDT, we limit the number of interviews to 24 conducted per sampling event.

We collected data regarding sexual risk-taking behavior from 2621 men (mean age 21.2 years) from May through August, 1999. Our sampling frame consisted of 140 venues (300 VDTs). Our venues were public sex environments, sex businesses, non-gay businesses that cater to the general public (such as train stations), informal organizations (social cliques), formal organizations, special events, and bars and clubs. Our final sample was generated from 17,024 men counted during 723 sampling events. Of 10,653 men whom we were able to intercept, we screened 7535 (71%). Of those, 2987 (40%) were eligible to participate, and 2621 men completed the interview, for a response rate of 88%.

Our final sample was comprised of 911 men under 21 years of age (34% of men who completed the interview). The age of our sample suggests we were successful in reaching younger men who do not have legal access to bars and clubs. Our sample is ethnically diverse, with participants who identify themselves as Latino (34%), African American (29%), and Asian and Pacific Islander (12%) (the remaining 25% is made up of whites, Native Americans, and some people who may have identified as other race/ethnicity). Men who identify as bisexuals comprise 24.4% of the sample and those who identify as gay comprise 67.2%. The remainder identify as heterosexual or not at all. The diversity of our sample suggests that the venue-based application of TSS can produce samples of YMSM that are quite diverse and can do so with relative efficiency.

Limitations of method. A significant limitation of venue-based application of TSS is that it assumes members of the target population attend venues that survey staff can access. Some members of the population may

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not attend the venues or may go very rarely. Because we are sampling from the universe of VDTs and not population members,[1] individuals who do not attend or rarely attend the venues have a near zero probability of being sampled compared with population members who attend often. Also, individuals entering heavily trafficked venues may have a lower probability of being enrolled than those entering low-density venues, unless the number of interviewers assigned to each venue compensates for population size at each venue.

Thus, depending on the extent to which associations between attendance and VDT selection affect the factors being measured, sampling biases may be introduced. Readers are referred to MacKeller[9] for formulae to weight data generated through venue-based sampling application of TSS methods to correct for bias introduced by differential frequency of attendance. This information is difficult to assess in a short interview and depends on the accuracy of attendees' recall. Information to be collected includes frequency of attendance at the venue, frequency of attendance at other venues, and time spent in the venue.

A complete or representative list of VDTs in the sampling frame is a key step to ensure that the method is carried out efficiently. Poor enumerations can misdirect resources to VDTs that may not yield adequate data, and productive VDTs may be missed if the earlier formative work is not thorough. Also, the sampling design is time intensive. In both the CITY and YMS projects, construction of the initial sampling frame required approximately two to three months, and CITY required one month of data collection to complete 60 interviews during 15 sampling events.

The venue-based application of TSS method is limited by its reliance on identifying the universe of VDTs that a population attends, which could lead to a bias of over- or under-representation if the VDTs of some social networks are not identified. Bias also can be introduced if researchers do not adhere carefully to design and implementation procedures. The method will produce a systematic sample only if there is no deviation from key procedures, such as uniformity in constructing sampling calendars and interviewing respondents for each place, time, and sampling wave.

DISCUSSION

The venue-based application of time space sampling used in the CITY project allowed researchers to collect data from a systematic sample of men who attend the venues included in the sampling frame. This method is not appropriate for obtaining information representative of all members of a targeted population who may live in a community, but it will produce a systematic sample of members of a targeted population who attend specific venues in a community. This design allowed us to sample young men who have sex with men systematically among many different catchment areas despite the difficulties presented when sampling this hard-to-reach population. The sampling statistics from summer 2000 were not complete for this publication. It appears, however, that many sites exhibited similar statistics from one year to the next. The venue-based application of TSS apparently allowed CITY investigators to implement a replicable method to generate a random sample of YMSM who attended venues in varied social situations and catchment areas in cityscapes. It is unlikely that comparable sampling statistics could have been achieved using any other method.

The venue-based application of TSS allows researchers to use screener information to target specific populations, and can generate a large and diverse sample. Screener information such as age, race, and residence can be used to interview only those people in the target population. This increases the efficiency of participant recruitment and effectively utilizes scarce resources (time, money, staff). Another strength of this method lies in the screening effect of venues and VDTs; a higher proportion of the people screened are members of the target population. By sampling during VDTs, researchers are able to increase the likelihood that people approached to be interviewed are members of the target population. The method, unlike

respondent-driven sampling, does not depend on the researchers gaining entry to specific social networks. While it is possible that the list of VDTs used in stage 1 may represent only one social network, the likelihood of this happening is remote. The venue-based application of TSS can be reproduced from place to place and time to time, thus allowing the method to be used in successive cross-sectional waves of data collection. Its ability to be replicated allows implementation by multi-site projects and assures comparability of data across sites even when targeting slightly different populations, as was the case with CITY. It produces a systematic sample with known properties, allowing researchers to minimize potential bias when measuring shifts in community norms and behaviors.

Because the TSS design is flexible on the key elements of updating the sampling frame and determining venue-day-time periods, researchers may be encouraged to adapt the method to the specific circumstances of their study populations. The systematic sampling methodology is maintained by identifying and randomizing all feasible VDTs, consistently scheduling the sampling calendar, and systematically sampling individuals at the events themselves. The special VDTs improve generalizability of results to the broader target population by reaching population members who might not attend traditional or specific venues that make up the majority of VDTs on a sampling frame.

Identification of the universe of VDTs attended by the population is the cornerstone of this method; multiple sources provide data that are triangulated to form a holistic picture of venues. As in targeted or outreach sampling, and for reasons such as safety and confidentiality, not all VDTs are feasible sampling events. But after the universe of VDTs is identified, this method calls for problematic VDTs to be removed *after* they have been identified in order to capture all elements of a targeted population, rather than haphazardly selecting venues or times based on staff convenience or preference.[12]

While the TSS method does not allow for inference to a geographically or demographically defined sample in the usual sense, it does produce a sample whose properties can be characterized. Careful consideration of the socialization habits of the population of interest allows the researcher to hypothesize about differences between the sample produced by VDT sampling and the population of interest. For example, current and former population members (older MSM) and members of their social networks can be interviewed and the data enumerated to make inferences about attendance of the target population at venues in the community.

The venue-based application of TSS can be used in part or in entirety by public health researchers or providers to evaluate where their target populations gather and how to gain access to those populations. The resulting data compilations may be useful to designers of outreach based interventions; for evaluation of placement of prevention services, social marketing materials, and other intervention materials based on population flow at specific locations; and to help direct resources to specific locations where targeted populations can be reached.

Additional members of the Community Intervention Trial for Youth (CITY) study team are: John Peterson (Georgia State Univ.); David Seal, Jeffrey A. Kelly (Medical College of Wisconsin); Kyung-Hee Choi (Univ. of California, San Francisco); Joseph Stokes (Univ. of Illinois at Chicago); Gary Remafedi (Univ. of Minnesota); Lydia O'Donnell (Education Development Center, Boston); Leslie Clark (Univ. of Alabama at Birmingham); Carolyn Guenther-Grey, Esther Sumartojo (Centers for Disease Control and Prevention).

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